### NASA/TM-2000-209891, Vol. 13



# Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Jeffrey A. Newcomer, Editors

## Volume 13 BOREAS AFM-06 Mean Temperature Profile Data

J. Wilczak

National Aeronautics and Space Administration

**Goddard Space Flight Center** Greenbelt, Maryland 20771

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### **BOREAS AFM-6 Mean Temperature Profile Data**

James Wilczak

### Summary

The BOREAS AFM-6 team from NOAA/ETL operated a 915-MHz wind/Radio Acoustic Sounding System (RASS) profiler system in the SSA near the OJP tower from 21-May-1994 to 20-Sep-1994. The data set provides temperature profiles at 15 heights, containing the variables of virtual temperature, vertical velocity, the speed of sound, and w-bar. The data are stored in tabular ASCII files.

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### 1. Data Set Overview

#### 1.1 Data Set Identification

BOREAS AFM-06 Mean Temperature Profile Data

#### 1.2 Data Set Introduction

This data set used the National Oceanic and Atmospheric Administration Environment Technology Laboratory (NOAA/ETL) 915-MHz wind/Radio Acoustic Sounding System (RASS) profiler data. Included in this data set are temperature profiles at 15 heights, containing the variables of virtual temperature, vertical velocity, the speed of sound, and w-bar. The data were collected near the BOReal Ecosystem-Atmospheric Study (BOREAS) Southern Study Area (SSA)-Old Jack Pine (OJP) tower site from May to September in 1994.

#### 1.3 Objective/Purpose

The BOREAS Airborne Fluxes and Meteorology (AFM)-06 team's field work objectives were to measure continuous hourly profiles of wind velocity and temperature in the atmospheric boundary layer (ABL) and lower troposphere, to measure the depth of the daytime convective boundary layer, and to measure the occurrence of precipitation, all using a 915-MHz radar wind/RASS profiler. The

data were then to be used to document average boundary layer structure, and especially changes in boundary layer structure during the course of the boreal summer growing season.

### 1.4 Summary of Parameters

Included in this data set are temperature profiles at 15 heights, containing the variables of virtual temperature, vertical velocity, the speed of sound, and w-bar.

### 1.5 Discussion

NOAA/ETL operated a 915-MHz wind profiling radar and surface meteorological station near the SSA-OJP continuously from 21-May-1994 through 20-Sep-1994. The data provided by the wind profiler are vertical profiles of wind speed and direction and virtual temperature, as well as boundary layer depth (Zi) and the presence of precipitation. These measurements were made with 100-m vertical resolution with the lowest measurement height at 150 m above ground level (AGL). The maximum height sampled was 3850 m AGL, although on many days the maximum height of the wind measurements was in the range of 2-3 km due to weak signal strength in the region of the lower troposphere above the ABL. Temperature profiles were routinely measured to heights of 500-1000 m.

### 1.6 Related Data Sets

BOREAS AFM-06 Boundary Layer Heights BOREAS AFM-06 Surface Meteorological Data BOREAS AFM-06 Mean Wind Profile Data

### 2. Investigator(s)

### 2.1 Investigator(s) Name and Title

Robert Banta, Brooks Martner, James Wilczak NOAA Environmental Laboratory

### 2.2 Title of Investigation

Outer Boundary Layer Effects on Surface Fluxes of Momentum, Heat, Moisture, and Greenhouse Gases from the Boreal Forest

#### 2.3 Contact Information

#### Contact 1:

James Wilczak NOAA/ETL 325 Broadway Boulder, CO 80303 (303) 497-6245 jwilczak@etl.noaa.gov

### Contact 2:

Jeffrey A. Newcomer Raytheon ITSS Code 923 NASA GSFC Greenbelt, MD 20771 (301) 286-7858 (301) 286-0239 (fax) Jeffrey.Newcomer@gsfc.nasa.gov

### 3. Theory of Measurements

The above measurements were obtained by measuring the zeroth, first, and second moments of the radar Doppler spectrum. The zeroth moment is the signal power. The range-corrected signal power can alternatively be expressed in terms of the turbulence structure parameter CN2. It is well-known that the vertical profile of CN2 exhibits a sharp peak at the midpoint of the inversion transition region, due to local mixing of relatively cool, moist boundary layer air with warmer and dryer air aloft. Our measurements of Zi were obtained from the peak value in the vertical profile of CN2 from a vertically pointing radar beam. The first moment of the Doppler spectrum is the Doppler velocity. The vertical profile of wind velocity was measured by combining the Doppler velocities measured along three radar beams: one vertical, and two oblique beams pointing at elevations of 75 degrees, oriented 90 degrees apart. The vertical profile of virtual temperature was measured using the RASS, in which an array of acoustic speakers surrounds the radar and generates a sound pulse. The radar signal reflects off of this acoustic wave front, and the measured Doppler shift indicates the velocity of the sound pulse, which is proportional to the virtual temperature of the air. The second moment of the Doppler spectrum, or spectral width, can provide a measure of the strength of the turbulence within the boundary layer. The second moment has not been directly used in the present analysis. Finally, the presence of precipitation is determined by using both signal power and the vertical velocity. Rain and snow have much greater signal power than does clear air, and nearly uniform downward velocities. Rain can be distinguished from snow by its greater reflectivity, and by its greater fall velocity. Because of the high sensitivity of the profiler, it is capable of detecting small amounts of rain that might not be measured by a traditional surface rain gauge. The profiler detects only the presence of precipitation, however, and at present cannot give a quantitative measure of rainfall amount.

### 4. Equipment

### 4.1 Sensor/Instrument Description

915-MHz wind profiling radar with RASS.

#### 4.1.1 Collection Environment

The 915-MHz profiler was used during various ambient weather conditions that occurred at the BOREAS SSA-OJP site.

### 4.1.2 Source/Platform

Ground-based.

### 4.1.3 Source/Platform Mission Objectives

The ground was used to support the needed instrumentation.

### 4.1.4 Key Variables

Included in this data set are temperature profiles at 15 heights, containing the variables of virtual temperature, vertical velocity, the speed of sound, and w-bar.

### 4.1.5 Principles of Operation

Standard Doppler radar techniques.

### 4.1.6 Sensor/Instrument Measurement Geometry

One vertical beam, two oblique beams 15 degrees from vertical at an elevation of 75 degrees.

### 4.1.7 Manufacturer of Sensor/Instrument

Wind Profiler: NOAA/ETL (Contact: James Wilczak at the address found in Section 2).

#### 4.2 Calibration

### 4.2.1 Specifications

None given.

#### **4.2.1.1 Tolerance**

None given.

### 4.2.2 Frequency of Calibration

None given.

### 4.2.3 Other Calibration Information

None given.

### 5. Data Acquisition Methods

During the course of 1 hour, the radar makes 18 cycles through each of the three radial beams, averaging for 60 seconds on each beam. These measurements require a total of 54 minutes. Prior to this, the RASS temperature profile is measured on the vertical beam during the first 5 minutes of the hour. During BOREAS, the RASS temperature observations consisted of 15 measurements, each 15 seconds in length. Each of these individual radial measurements of both wind and temperature is then quality controlled through an automated pattern recognition scheme, and then the measurements are combined into a single value of wind and temperature reported for each hour.

### 6. Observations

### 6.1 Data Notes

The wind profiler operated unattended for most of the 4-month observation period.

#### **6.2 Field Notes**

The wind profiling radar and surface meteorological stations were located at a site 1.0 km south and 1.6 km east of the OJP tower flux site. The radar site was in a clearing in the jack pine forest, with fetches (clear distances) of 200 m to the north, 500 m to the south, 150 m to the east, and 1 km to the west. Ground cover within the clearing consisted of grass, brush, and young jack pine trees, approximately 1-2 m tall.

### 7. Data Description

### 7.1 Spatial Characteristics

#### 7.1.1 Spatial Coverage

The North American Datum of 1983 (NAD83) coordinates of the site are:

Lat. =  $53.91 \, ^{\circ}N$ Long. =  $104.40 \, ^{\circ}W$ 

Alt. = 511 m above sea level

This location is 1.0 km south, and 1.6 km east of the SSA-OJP flux tower.

### 7.1.2 Spatial Coverage Map

Not available.

### 7.1.3 Spatial Resolution

```
Beamwidth = 9.9 degrees (one-way, 3 dB)
Range resolution = 101 m
Range limits = 0.112-3.889 km AGL (38 range gates)
```

### 7.1.4 Projection

Not applicable.

### 7.1.5 Grid Description

Not applicable.

### 7.2 Temporal Characteristics

### 7.2.1 Temporal Coverage

Measurements were made from 21-May-1994 through 20-Sep-1994.

### 7.2.2 Temporal Coverage Map

Not available

### 7.2.3 Temporal Resolution

Measurements were made 15 times per hour during the period.

### 7.3 Data Characteristics

#### 7.3.1 Parameter/Variable

Column Name

The parameters contained in the data files on the CD-ROM are:

\_\_\_\_\_\_ SITE NAME SUB\_SITE DATE\_OBS TIME\_OBS HT\_ASL VIRT\_TEMP VERT\_VELOC SPEED\_OF\_SOUND MEAN\_VERT\_VELOC CONSEN\_NUM\_VIRT\_TEMP SNR\_VIRT\_TEMP CONSEN\_NUM\_VERT\_VELOC SNR\_VERT\_VELOC NUM\_LVLS QUAL\_CONTROL CRTFCN\_CODE REVISION\_DATE

### 7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
TIME_OBS	The Greenwich Mean Time (GMT) when the data were collected.
HT_ASL	The height above mean sea level at which the measurements were taken.
VIRT_TEMP	The measured virtual temperature, with a correction for vertical velocity.
VERT_VELOC	The measured vertical velocity.
SPEED_OF_SOUND	The measured speed of sound.
MEAN_VERT_VELOC	The measured mean vertical velocity.
CONSEN_NUM_VIRT_TEMP	Consensus number on virtual temperature.
SNR_VIRT_TEMP	The signal to noise ratio for virtual temperature.
CONSEN_NUM_VERT_VELOC	Consensus number on vertical velocity.
SNR_VERT_VELOC	The signal to noise ratio for vertical velocity.
NUM_LVLS	The number of height levels in the atmospheric profile.
QUAL_CONTROL	A quality control parameter. A value of 0 or 1 can be considered good. A value of 7 or 8 indicates suspect or bad data:  QC Code Definition: 0 Valid  1 Estimated  7 Suspect  8 Invalid
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

For the columns VIRT\_TEMP, VERT\_VELOC, SPEED\_OF\_SOUND, MEAN\_VERT\_VELOC, CONSEN\_NUM\_VIRT\_TEMP, SNR\_VIRT\_TEMP, CONSEN\_NUM\_VERT\_VELOC, SNR\_VERT\_VELOC the following data definitions apply:

Data Code Definition: -940 --- Failed QC,

-950 --- Failed Consensus -960 --- Exceeded Nyquist Vel. -980 --- Flagged by Reviewer -999 --- Missing or Not Reported

### 7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units	
SITE NAME	[none]	
<del>_</del>		
SUB_SITE	[none]	
DATE_OBS	[DD-MON-YY]	
TIME_OBS	[HHMM GMT]	
HT_ASL	[meters]	
VIRT_TEMP	[degrees Celsius]	
VERT_VELOC	[meters][second^-1]	
SPEED_OF_SOUND	[meters][second^-1]	
MEAN_VERT_VELOC	[meters][second^-1]	
CONSEN_NUM_VIRT_TEMP	[unitless]	
SNR_VIRT_TEMP	[unitless]	
CONSEN_NUM_VERT_VELOC	[unitless]	
SNR_VERT_VELOC	[unitless]	
NUM_LVLS	[unitless]	
QUAL_CONTROL	[unitless]	
CRTFCN_CODE	[none]	
REVISION_DATE	[DD-MON-YY]	

### 7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by NOAA/ETL]
TIME_OBS	[Supplied by NOAA/ETL]
HT_ASL	[Supplied by NOAA/ETL]
VIRT_TEMP	[Supplied by NOAA/ETL]
VERT_VELOC	[Supplied by NOAA/ETL]
SPEED_OF_SOUND	[Supplied by NOAA/ETL]
MEAN_VERT_VELOC	[Supplied by NOAA/ETL]
CONSEN_NUM_VIRT_TEMP	[Supplied by NOAA/ETL]
SNR_VIRT_TEMP	[Supplied by NOAA/ETL]
CONSEN_NUM_VERT_VELOC	[Supplied by NOAA/ETL]
SNR_VERT_VELOC	[Supplied by NOAA/ETL]
NUM_LVLS	[Supplied by NOAA/ETL]
QUAL_CONTROL	[Supplied by NOAA/ETL]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

### 7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

CD-ROM.	Minimum	Maximum	Missng	Unrel	Below	Data
	Data	Data	Data	Data	Detect	Not
Column Name		Value				
SITE_NAME		SSA-OJP-RDR01			None	None
SUB_SITE	AFM06-RDR01	AFM06-RDR01	None	None	None	None
DATE_OBS	21-MAY-94	21-SEP-94	None	None	None	None
TIME_OBS	5	2305	None	None	None	None
HT_ASL	639	2109	None	None	None	None
VIRT_TEMP	-950	33.3	-999	None	None	None
VERT_VELOC	-950	23.9	-999	None	None	None
SPEED_OF_SOUND	-950	950	None	None	None	None
MEAN_VERT_VELOC		950	None	None	None	None
CONSEN_NUM_VIRT_TEMP		16	None	None	None	None
SNR_VIRT_TEMP		18	None	None	None	None
CONSEN_NUM_VERT_	-950	16	None	None	None	None
VELOC						
SNR_VERT_VELOC		36	None	None	None	None
NUM_LVLS	15	15	None		None	None
QUAL_CONTROL	0	7	None			None
<u> </u>	CPI				None	
REVISION_DATE		22-AUG-96	None	None	None	None
Minimum Data Value Maximum Data Value Missng Data Value	<ul><li>The minimum v</li><li>The maximum v</li><li>The value that indicate that parameter val</li></ul>	alue found in t t indicates mis an attempt was ue, but the att	the columnsing dates made to the tempt was	n. a. This determ unsucc	ine the essful.	
Unrel Data Value -		t indicates unr n attempt was m				used

to indicate an attempt was made to determine the parameter value, but the value was deemed to be

unreliable by the analysis personnel. Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection

limit of the instrumentation.

-- This value indicates that no attempt was made to Data Not Cllctd determine the parameter value. This usually

indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not

measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value. N/A -- Indicates that the value is not applicable to the respective column.

None -- Indicates that no values of that sort were found in the column.

\_\_\_\_\_\_

### 7.4 Sample Data Record

The following are wrapped versions of data records from a sample data file on the CD-ROM.

```
SITE_NAME, SUB_SITE, DATE_OBS, TIME_OBS, HT_ASL, VIRT_TEMP, VERT_VELOC, SPEED_OF_SOUND, MEAN_VERT_VELOC, CONSEN_NUM_VIRT_TEMP, SNR_VIRT_TEMP, CONSEN_NUM_VERT_VELOC, SNR_VERT_VELOC, NUM_LVLS, QUAL_CONTROL, CRTFCN_CODE, REVISION_DATE
'SSA-OJP-RDR01', 'AFM06-RDR01', 21-MAY-94, 5, 639, -999.0, 1.69, 332.35, -1.19, 12, -11, 14, 2, 15, 7, 'CPI', 22-AUG-96
'SSA-OJP-RDR01', 'AFM06-RDR01', 21-MAY-94, 5, 744, -999.0, 1.28, 332.1, -1.12, 13, -2, 14, 10, 15, 7, 'CPI', 22-AUG-96
'SSA-OJP-RDR01', 'AFM06-RDR01', 21-MAY-94, 5, 954, -999.0, .08, 331.38, -1.04, 14, -15, 14, 5, 15, 7, 'CPI', 22-AUG-96
```

### 8. Data Organization

### 8.1 Data Granularity

The smallest unit of data tracked by the BOREAS Information System (BORIS) was the data collected at a given site on a given date.

### **8.2 Data Format(s)**

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

### 9. Data Manipulations

### 9.1 Formulae

### 9.1.1 Derivation Techniques and Algorithms

None given.

### 9.2 Data Processing Sequence

#### 9.2.1 Processing Steps

During the course of I hour, the radar makes 18 cycles through each of the three radial beams, averaging for 60 seconds on each beam. These measurements require a total of 54 minutes. Prior to this, the RASS temperature profile is measured on the vertical beam during the first 5 minutes of the hour. During BOREAS, the RASS temperature observations consisted of 15 measurements, each 15 seconds in length. Each of these individual radial measurements of both wind and temperature is then quality controlled through an automated pattern recognition scheme, and then the measurements are combined into a single value of wind and temperature reported for each hour.

### 9.2.2 Processing Changes

None given.

#### 9.3 Calculations

### 9.3.1 Special Corrections/Adjustments

None given.

### 9.3.2 Calculated Variables

None given.

### 9.4 Graphs and Plots

None given.

### 10. Errors

### 10.1 Sources of Error

During spring and autumn seasons, it is possible that the profiler winds can be contaminated by the presence of migrating birds. These errors are now well understood, and can be recognized from large values of signal power, spectral width, and sudden changes in wind speed occurring near sunset and sunrise. Periods of contaminated winds have been hand edited from the data set. Birds do not directly affect RASS temperatures, although they could have a secondary effect by contaminating vertical velocity, which is used to correct RASS temperatures. No corrections for contaminated vertical velocities on RASS have been made.

### **10.2 Quality Assessment**

### 10.2.1 Data Validation by Source

See Section 10.2.3.

### 10.2.2 Confidence Level/Accuracy Judgment

See Section 10.2.3.

### **10.2.3 Measurement Error for Parameters**

During the first 3 days and last 3 days of operation, ETL personnel were at the site taking balloon intercomparisons. These assessments have shown typical values of agreement of the balloons with profiler, typically 1-2 m/s and 1 deg C. Wind velocity differences between 915-MHz wind profilers and precision research aircraft have been found to be on the order of 0.9 m/s.

### 10.2.4 Additional Quality Assessments

None given.

### 10.2.5 Data Verification by Data Center

BORIS personnel verified that the delivered data agreed with the information provided by the AFM-06 team.

#### 11. Notes

### 11.1 Limitations of the Data

None given.

### 11.2 Known Problems with the Data

None given.

### 11.3 Usage Guidance

None given.

#### 11.4 Other Relevant Information

None given.

### 12. Application of the Data Set

These data can be used with the other AFM-06 SSA-OJP data to observe the dynamics of the local atmosphere.

### 13. Future Modifications and Plans

None given.

### 14. Software

### 14.1 Software Description

None given.

### 14.2 Software Access

None given.

### 15. Data Access

The mean temperature profile data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

#### **15.1 Contact Information**

For BOREAS data and documentation please contact:

ORNL DAAC User Services Oak Ridge National Laboratory P.O. Box 2008 MS-6407 Oak Ridge, TN 37831-6407

Phone: (423) 241-3952 Fax: (423) 574-4665

E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

### 15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/ [Internet Link].

#### 15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

#### 15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

### 16. Output Products and Availability

### **16.1 Tape Products**

None.

### 16.2 Film Products

None.

#### 16.3 Other Products

These data are available on the BOREAS CD-ROM series.

### 17. References

### 17.1 Platform/Sensor/Instrument/Data Processing Documentation

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### 17.2 Journal Articles and Study Reports

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# 17.3 Archive/DBMS Usage Documentation None.

### 18. Glossary of Terms

None.

### 19. List of Acronyms

ABL - Atmospheric Boundary Layer

AFM - Airborne Fluxes and Meteorology

ASCII - American Standard Code for Information Interchange

BOREAS - BOReal Ecosystem-Atmosphere Study

BORIS - BOREAS Information System

CD-ROM - Compact Disk - Read-Only Memory
DAAC - Distributed Active Archive Center

EOS - Earth Observing System

EOSDIS - EOS Data and Information System

ETL - Environment Technology Laboratory

GIS - Geographic Information System

GMT - Greenwich Mean Time

GSFC - Goddard Space Flight Center HTML - HyperText Markup Language NAD83 - North American Datum of 1983

NASA - National Aeronautics and Space Administration NOAA - National Oceanic and Atmospheric Administration

NSA - Northern Study Area

OJP - Old Jack Pine

ORNL - Oak Ridge National Laboratory
PANP - Prince Albert National Park
RASS - Radio Acoustic Sounding System

SSA - Southern Study Area
URL - Uniform Resource Locator

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The BOREAS AFM-6 team from NOAA/ETL operated a 915-MHz wind/Radio Acoustic Sounding System (RASS) profiler system in the SSA near the OJP tower from 21-May-1994 to 20-Sep-1994. The data set provides temperature profiles at 15 heights, containing the variables of virtual temperature, vertical velocity, the speed of sound, and w-bar. The data are stored in tabular ASCII files.

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